Dechlorination of PCBs during Anaerobic Sludge Digestion

Devrim Kaya (devkaya@gmail.com) and Birthe V. Kjellerup (bvk@umd.edu) (University of Maryland College Park, College Park, MD, USA)
Kevin R. Sowers (sowers@umbc.edu) (University of Maryland Baltimore County, Baltimore, MD, USA)

Background/Objectives. Despite their production for industrial use and discharge ban since late 1970s, thousands of metric tons of commercial polychlorinated biphenyls (PCBs), manufactured under the trade name Aroclor in the U.S., contamination of the environment with PCBs still occurs and is of great public concern which has led the European Union and many other countries to regulate the PCB concentrations in air and water as well as sludge. Motor and transformer oils are considered as the main sources of PCB released into the environment and frequently contained Aroclor 1254 (A1254).Sales records of Monsanto U.S. (the leading PCB manufacturer globally) indicated A1254 as the second most produced/sold Aroclor mixture. A1254 has been found in sludge, sediment, and soil around the globe. A1254 is the most toxic PCB mixture with 8-16 times more toxic than A1248 and 3-6 times more than A1242 and 1260, primarily due to its large percentage of congeners with the dioxin-like properties. The aim of this study was to investigate the dechlorination of PCBs through A1254 mixed with or without transformer oil (TO) in sewage sludge digester and to evaluate the performance of anaerobic sludge digester through chemical oxygen demand (COD) and volatile solids (VS) content, and biogas composition.

Approach/Activities. Glass bottles (60-mL) were used as simulated lab-scale anaerobic sludge digesters to investigate the dechlorination potential of A1254 (100 ppm) together with the effect of TO (1% oil, v/v) on PCB dechlorination, and sludge digester performance. Grasse River (NY, USA) sediment was used as an acclimated culture/inoculum. Sludge collected from the return line of secondary sedimentation tank of Little Patuxent Water Reclamation Plant (Baltimore, MD, USA) was used as the electron donor and carbon source. All microcosms were prepared in triplicate and incubated for 120 days in dark at 30°C.

Results/Lessons Learned. A1254 dechlorination rates were observed within sludge microcosms with TO amendment, indicating a negative effect of TO on dechlorination. Dechlorination occurred mostly through *meta*chlorine removal followed by *para*removals thus following process N and H/H' dechlorination patterns from literature. Penta-, followed by hexa- and hepta-chlorinated congeners of A1254 were predominantly dechlorinated by 81%, 77%, and 77%, respectively, in sludge digesters without TO amendment. In contrast, relatively lower A1254 dechlorination occurred mostly through dechlorination of penta- (67%) and hexa-chlorinated congeners (48%) with TO amendment. As a result, the toxicity of dioxin-like congeners was reduced by approximately 88% and 68% without or with TO amendment, respectively. Methane productions were decreased by 6% during A1254 dechlorination with TO amendment. COD and VS removals, indicative of sludge digester performance, were between 35-53% and 34-55%, respectively, which are similar to typical sludge digester ranges, 40-60%. Methane production rates were between 883 and 1116 mL CH_4/g of VS destroyed and were a function of presence of TO and/or PCBs, consistent with prior reports of 750-1120 mL/g of VS destroyed. The presence of PCB dechlorinating bacteria related to *Dehalococcoides mccartyi*(known for having a key role in dechlorination) was confirmed. Overall, PCBs were dechlorinated during anaerobic sludge digestion, indicating potential use of anaerobic digesters in wastewater treatment plants for PCB removals.